THE WATERPROOFING OF FABRICS

BY

DR. S. MIERZINSKI

TRANSLATED FROM THE GERMAN BY
ARTHUR MORRIS AND HERBERT ROBSON, B.Sc.

Second Revised and Enlarged Edition
WITH TWENTY-NINE ILLUSTRATIONS

LONDON
SCOTT, GREENWOOD & SON
8 BROADWAY, LUDGATE, E.C.
1914

*[The sole right of translation into English remains with
Scott, Greenwood & Son]*

First English Edition 1903
Second English Edition, Revised and Enlarged. January, 1914

TRANSLATORS' PREFACE

ABRIDGMENTS of English waterproofing patents have been added in order to bring it up to date. It may be taken for granted that if a process is worth anything it is patented in England.

The author deals almost solely with the waterproofing of fabrics, but we have gone outside this limit in our selection of patents.

CONTENTS.

CHAPTER I.

INTRODUCTION.

Definition—Relative and Absolute Impermeability—Appearance of a Waterproofed Fabric under the Microscope—Fabrics to be Waterproofed must be tightly Woven . . . . . . *pages* 1-4

CHAPTER II.

PRELIMINARY TREATMENT OF THE FABRIC.

Scouring the Fabric to be Waterproofed with Soda Lye . *pages* 5-13

CHAPTER III.

WATERPROOFING WITH ACETATE OF ALUMINA.

Preparation of Aluminium Acetate—Filter Press—Chamber Presses—Frame Presses—Three-chamber Filter Press . . *pages* 14-20

CHAPTER IV.

IMPREGNATION OF THE FABRIC.

Impregnation by Steeping—Vacuum Plant for Impregnating Fabrics with Waterproofing Liquors . . . . . . *pages* 21-27

CHAPTER V.

DRYING.

Drying Rooms—Ventilation of Drying Rooms—Apparatus for Feeding Drying Room with Fabrics—Stove for Heating the Drying Air—Drying Machines—Preparation of Absolutely Waterproof Fabrics—Use of Soap—Incorporation of Rubber in Soap Solutions—A Special Soap-rubber Composition—Calendering the Waterproofed Fabric—Testing the Finished Goods—The Rational Use of Paraffin in Remedying Defects . . . . *pages* 28-41

CHAPTER VI.

WATERPROOFING WITH PARAFFIN WAX.

Ceresine—Method of Waterproofing Fabrics with Paraffin—Impregnating Fabrics with Fused Ceresine by Aid of Hot Rolls—An Improved Process—Calendering Fabrics Impregnated with Paraffin *pages* 42-49

CHAPTER VII.

WATERPROOFING WITH AMMONIUM CUPRATE.

Differentiation between Waterproofing with Ammonium Cuprate and Aluminium Acetate—Solvent Action of Ammonium Cuprate on Cellulose—Preparation of Ammonium Cuprate—A More Simple Method—Method of Waterproofing with Ammonium Cuprate—Breitenfeld's Process—Hime's Process . . . *pages* 50-53

CHAPTER VIII.

WATERPROOFING WITH INSOLUBLE SOAPS OF METALLIC OXIDES . . . . *page* 54

CHAPTER IX.

DYEING WATERPROOF FABRICS.

Adjective and Substantive Dyes—Dyewoods—Dyeing of Hemp, Linen and Jute—One-dip and Two-dip Processes—Dyeing Machinery—Waterproofing Process for Dyed Goods—Testing of Dyed Waterproofed Goods—Testing Fastness to Washing of Dyed Waterproofed Fabrics—Testing Fastness to Friction of Dyed Waterproofed Fabrics—Testing Fastness of Dye to Perspiration . *pages* 55-59

CHAPTER X.

WATERPROOFING WITH GELATINE, TANNIN, CASEINATE OF LIME, AND OTHER BODIES.

Waterproofing with Gelatine, etc.—Leather Brown Colour of Goods—Muratori and Landry's Process—Quality of Goods—Muzmann and Krakowitzer's Process—Dumas's Process—Waterproofing with Solution of Alumina Soap—Waterproofing with Lime Resinate Varnish—Schulke's Process—Waterproofing Wool and "Tweed" Goods—Waterproofing with Caseinate of Lime—Preparation of Casein from Milk—Benzinger's Collodion Process . *pages* 60-66

CHAPTER XI.

MANUFACTURE OF TARPAULIN.

Tarred Fabrics—Preparation of Tar—The Tarring of Fabrics—Hand Spreading of Tar versus Mechanical Spreading—Spreading Machines—Uneven Spreading—Testing Tarpaulins—Drying of Freshly Tarred Tarpaulins—Honzeau and Maison's Process—Dubret's Process—Döring's Process . . . *pages* 67-76

CHAPTER XII.

BRITISH WATERPROOFING PATENTS . . . . *pages* 77-128

INDEX . . . . *pages* 129-132

WATERPROOFING OF FABRICS.

CHAPTER I.

INTRODUCTION.

Definition.—Waterproof fabrics are those which, by covering over and impregnating the fibres and filling up the interstices between them with a substance insoluble in, and impermeable to, water, are not only protected from the destructive effect of dew, rain, hail, snow, etc., but the objects covered thereby, more especially perishable goods, are also protected from these atmospheric influences. Waterproof garments are also used to protect persons from rain, and to enable them to wade about in water with impunity. Fabrics are rendered waterproof by impregnating them with fats, oils, varnishes, pigments, guttapercha, indiarubber, oxides, acids, and metallic salts and other media. Little has been written on the subject, and the few writers who have dealt with it cannot be congratulated upon their efforts. It is customary to include under waterproofing such processes as the impregnation of wood and paper pulp, the manufacture of waxcloth, and of articles of indiarubber and guttapercha, etc. The term should, however, be restricted to the treatment of fabrics by chemical means, so as to precipitate insoluble oxides in the fibre, or the impregnation of the fibre with organic bodies, such as paraffin wax, etc., so as to make it impervious.

Relative and Absolute Impermeability.—Absolute impermeability can never be attained, and does not exist, even if the fabric has shown itself watertight for weeks or even months. If a pouch is made of a waterproof fabric, and kept full of water, we notice at last that the colour of the outside begins to change up to the level of the water inside, without the water itself showing. The outside often, too, begins to get mouldy. These appearances prove that the water has to some extent penetrated the fabric. They occur sooner if the waterproofing has been done with aluminium acetate, as the basic alumina salts in the fibre gradually dissolve. There is no such thing as a substance absolutely insoluble in water, more especially in naturally occurring waters.

Appearance of a Waterproofed Fabric under the Microscope.—Materials, when waterproofed by chemical agents, undergo changes only visible under the microscope. If an untreated fibre be put under the microscope, and then brought into contact with a drop of water, it will be seen to suck up the water greedily. But if it has been treated with alumina the water is not absorbed, and the drop looks like a pearl traversed by the dark threads. Many air-bells crowd round the separate threads and stick to them very obstinately, so that even hard pressure with the cover glass does not get rid of them. The behaviour of coloured fibres is different after they have been waterproofed with acetate of alumina or a metallic soap. Here we usually find both the dye as a lake and the metallic oxide adhering to the fibre. If, however, the waterproofing be done with ammonium cuprate or other ammoniacal solutions of metallic oxides, not only is the deposit of metallic oxide to be seen, but it is evident that the fibre has been altered and parchmentized.

Fabrics To Be Waterproofed Must Be Tightly Woven.—A fabric to be waterproofed must be woven very tightly, e.g. the cotton fabric known as "duck". It does not matter whether its material is animal or vegetable. By chemical impregnation the fibres must be made to keep back the water mechanically, and the interstices between the threads should not be filled up. A very closely woven fabric is highly impervious of itself, and will resist water as long as the fibre takes it up without allowing it to pass through. In waterproofing light, thin-fibred or wide-meshed fabrics, therefore, they have to be treated with a composition which will fill up the interstices and afford protection as long as possible against outward agencies. This treatment, however, alters the whole fabric. The threads become stiffer, more brittle and less durable, while fabrics waterproofed by chemical means undergo no striking change. Not only should fabrics to be waterproofed be tightly woven, but there should be no flaw in the sewing of the seams. Such flaws constitute the weak links in the chain and mar the effect of even the best waterproofing.

It has been already mentioned that fabrics are waterproofed by impregnating them with fats, such as linseed oil, boiled oil, etc., or made impervious by applications of ndiarubber, varnish, resin, pitch, tar, paints, etc. Such methods give a protective coating which protects from the weather exactly as wood and other constructive materials are protected. These latter methods, however, not only produce a coating which repels water, but one which also repels air. Those processes which are usually called chemical, and also those which act by stopping up the cells and pores of the fabric with an easily deposited substance are quite pervious to air. This can readily be demonstrated by moistening the fabric with the saliva and blowing through the fabric from the other side when large air bells rise out of the saliva. In the former case, precipitates of insoluble metallic compounds or of insoluble metallic soaps are produced in and upon the fibre by chemical reactions. In the latter, the fibres are soaked with paraffin, wax, etc., in solution. The solvent quickly evaporates and leaves the paraffin, etc., behind in a state of very fine division. Both classes of process yield products in which the fabric has suffered no change visible to the naked eye, but the paraffin coat is air-tight for a time until the folding-up in the cold of the garment breaks up the then brittle layer of paraffin. According to the treatment the impermeability to water is limited or practically boundless, and the fabrics retain their original colour, softness and suppleness, except in a very few cases. For example, if tannin is used, the colour of the fabric becomes somewhat darker, but only an expert would notice the difference.

If a bleached or unbleached fabric is waterproofed with acetate of alumina, its appearance and "feel" remain exactly as at first. The following substances are used in particular for waterproofing fabrics: sulphate of alumina, alum, acetate of lead, the sulphates of copper, zinc and iron, ammonium cuprate, chromate of potash, paraffin, ceresine, wax, soap, etc.

CHAPTER II.

PRELIMINARY TREATMENT OF THE FABRIC.

Scouring the Fabric To Be Waterproofed with Soda Lye.—The fabric to be waterproofed must, if unbleached, first be boiled with soda lye, so as partly to remove the colouring principle and grease in the fibre. Hemp, linen and jute fibres offer great resistance to taking up water, on account of their greasy nature. Half or entirely bleached fibres have the peculiarity that they do not readily absorb the waterproofing fluid, so that they, too, must be scoured. The scouring is best done with a 3 to 5 per cent solution of carbonate of soda, either in large paraffined wooden vats, or, better, in iron boilers, which have been painted inside thickly with asphaltum varnish (a solution of natural asphaltum in benzine or oil of turpentine, mixed with some good copal varnish). The vessels must be large enough to take several pieces at once. Whether of wood or iron, they must always have a false, perforated bottom and a heating coil of copper tubing.

The soda ash (ammonia soda is the best) is dissolved in water and poured over the goods placed, loosely tied up, on the false bottom of the boiler. The lid, in which there is a pipe for the escape of steam, is then put on and the contents are boiled up. It is best not to use direct steam, and to make up the water as it evaporates. Condensed water from the escape steam of the factory engine still hot, should be used for this purpose. After boiling for an hour or two, the steam is shut off, and the boiler left for about twelve hours. The dirty water is then run off through a cock below the false bottom. It rarely pays to recover the soda from the dirty soda solution, although it may be worth while under very special local conditions. The above pro-

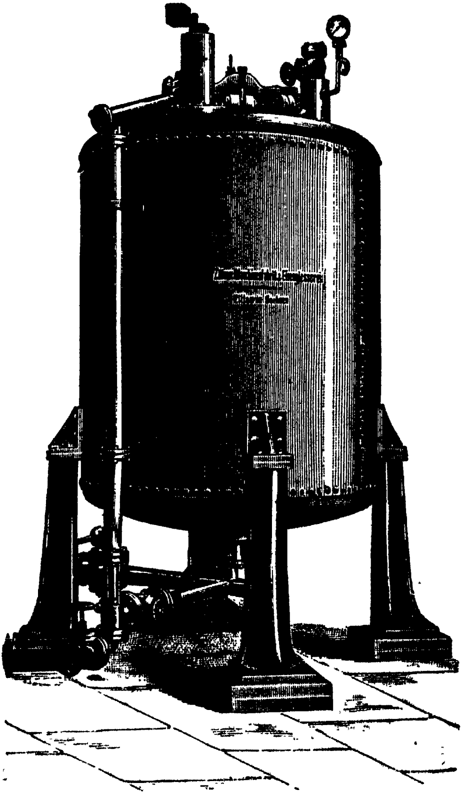

FIG. 1.—High Pressure Boiler for Scouring Fabrics (to be Waterproofed) with Soda Lye.

cess is done quicker and better under pressure. Fig. 1 shows a high-pressure boiler of wrought iron, tested to eight atmospheres pressure, and fitted with a manhole. In the centre a turbine is fitted, which, in rotating, pours the soda solution, made to flow through it by the action of a pump or injector, uniformly over the fabrics. The apparatus is heated by high-pressure steam. Fig. 2 shows a different system. The boiler resembles an ordinary kier. The fabric, A, is piled on the false bottom, C. A pipe, D, brings the soda solution from below, and it is discharged over the goods by E. The soda is forced up D by the pressure of the steam. This system acts intermittently, as

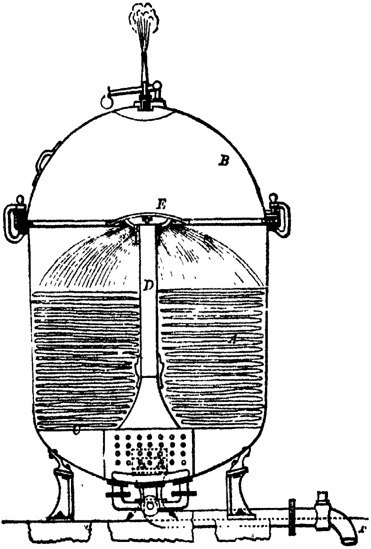

FIG. 2.—Kier for Scouring Fabrics to be Waterproofed.

after each outburst from E the pressure of the steam must increase, till it again overcomes the weight of the liquid in D. When the goods are scoured in one of these boilers, clean water is run over them so as to wash them completely, that is till the soda is completely washed out. This process can be hastened by acidifying the first wash-water with sulphuric or hydrochloric acid. This acidifying process in bleaching language is termed souring and the acid liquid is termed a sour. Instead of scouring, the goods can be washed with a full-width washing machine (Fig. 3), with a divided wooden chest with rotating vanes in it. The washed and rinsed pieces are either hung up to dry, or centrifuged, or dried on a cylinder drying machine. A horizontal hydro-extractor, such as is shown in Fig. 4, is the best, and in this the fabric is drawn on to a drum and then centrifuged. Another type is the full-width hydro-extractor shown in Fig. 5. This machine works quietly at a great number of revolutions, is

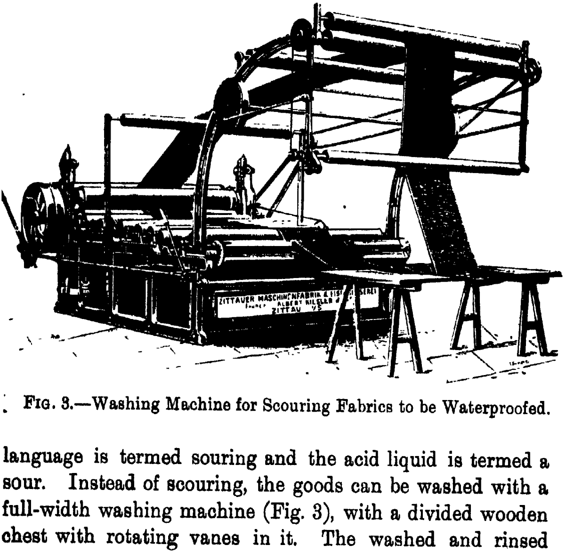

FIG. 3.—Washing Machine for Scouring Fabrics to be Waterproofed.

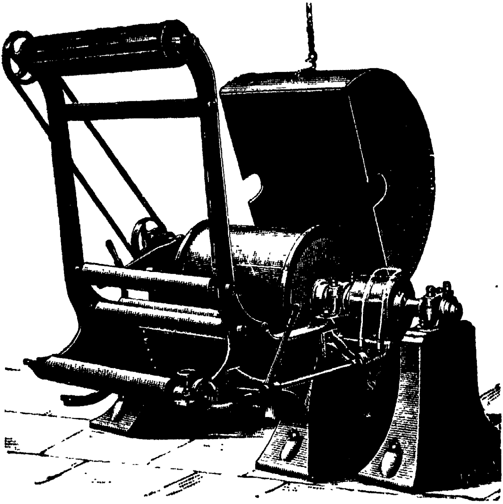

FIG. 4.—Horizontal Hydro-Extractor.

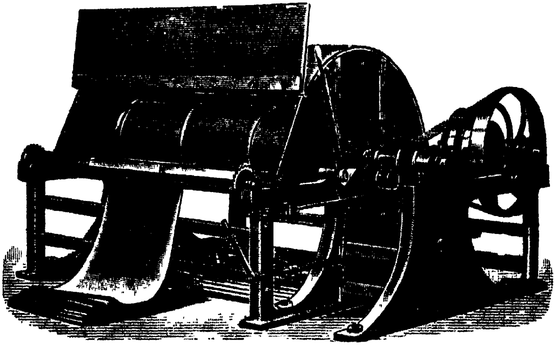

FIG. 5.—Full Width Hydro-Extractor.

readily accessible, and does not consume much power Simpler and more effective, however, is the machine shown in Fig. 6. On a horizontal axis four boxes are arranged, which have bottoms and sides of strong iron rods. Each will hold one or two pieces of fabric. When they are all full, lids are put on them and the axis is rotated. Centrifuging in this way causes no creases.

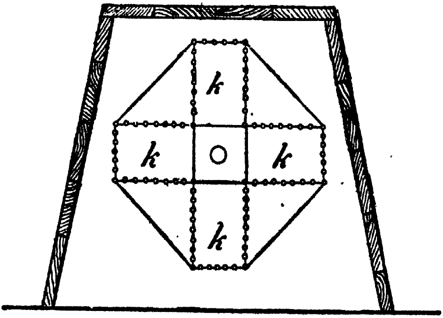

FIG. 6.—Centrifugal Machine.

Roller drying machines (Fig. 7) are largely used. They consist of a varying number of hollow copper rolls, and are heated by steam. The ends of the rolls are steam-tight, and draw the fabric through the machine by friction. The speed is regulated by suitable gearing. The machine is provided with stretching frame and rolls for receiving the dried goods. In machines with two rows of rolls, both sides of the goods come into contact with the hot rolls. Care must be taken that the diameter of the rolls is not too great. It should not exceed 22½ inches, as repeated experience has shown that small rolls are much to be preferred to larger ones. This is easily understood if we compare the useful surface with the useless, *i.e.*, the curved surface with the surface of the roller ends. If we compare one roll of 3 metres diameter with three each of 1 metre, we get the same result for the total circumference in both cases, viz., 9·42 metres. But the ends of the 3-metre roll have a total area of 2 × $\frac{9}{4}$ × 3·14 = 14·13 square

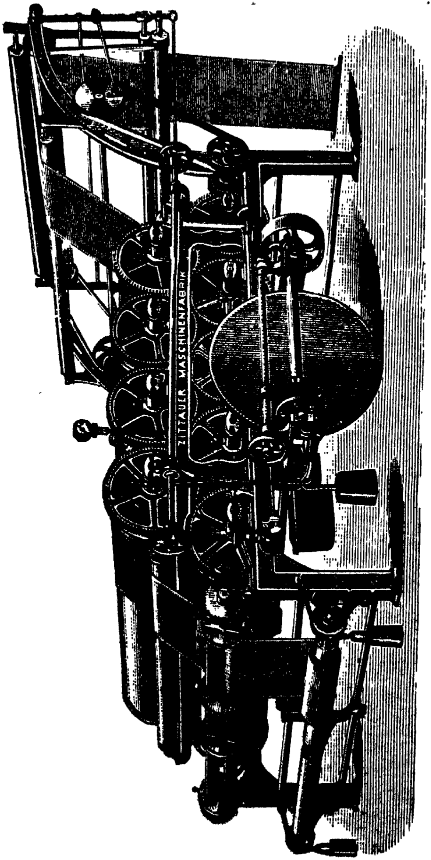

FIG. 7.—Drying Rolls (Hot).

metres, and the total area of the six ends of the 3-metre rolls is 6 × ¼ × 3·14 = 4·71 square metres only. Hence the surface which has no drying action, and which wastes heat by radiation, is much smaller in the case of the small rolls, while the useful surface is the same. Besides, having a large number of rolls permits a more gradual raising of the temperature than is possible with only a few rolls. Small rolls, too, are more easily removed and replaced than big ones.

Another advantage with smaller rolls is that the goods pass more quickly from roll to roll, and there is much less risk of the goods clinging to the rolls than with large rolls. The different rolls must all be of the same diameter, and be turned quite true, so that the fabric will travel uniformly. The foundations of the machine must be solid. The steam enters the rolls through their hollow axes, and condensed water is run off in the same way. The bearings may be connected with the steam-tight rolls, without any packing, by a system of exactly turned wrought-iron rings. To get the full efficiency of the machine, all water that condenses in the rolls must be at once got rid of. The Hanbold arrangement fixed to each end of the roll for this purpose is excellent. The lifting tubes often used have the disadvantage that they only remove the condensed water partially, and not at all if the steam pressure falls below a certain amount. Empties bolted or soldered to the roller case are no better. If they are bolted, the bolts become loose, and the fabric gets wet stains, while if they are soldered, the solder soon gives out, and the arrangement ceases to act. To protect the rolls from collapsing by the formation of a vacuum in them, it is not sufficient to have simple air valves in the roller ends. There should be an air valve also over the bearings of the roll. Where there is lack of room, upright drying machines should be used. A very compact power drier of this type, with thirty rolls, is shown in Fig. 8. The construction is evident without verbal explanation.

The drying of the fabrics on these machines demands great care in maintaining an equable temperature. The copper rolls, too, must be kept scrupulously clean, or the fabric will be marked by them with stains which will not take the waterproofing liquid properly and will show in the finished goods. My experience is that it is best of all to dry in a full-width hydro-extractor, which turns out the fabric ready for waterproofing.

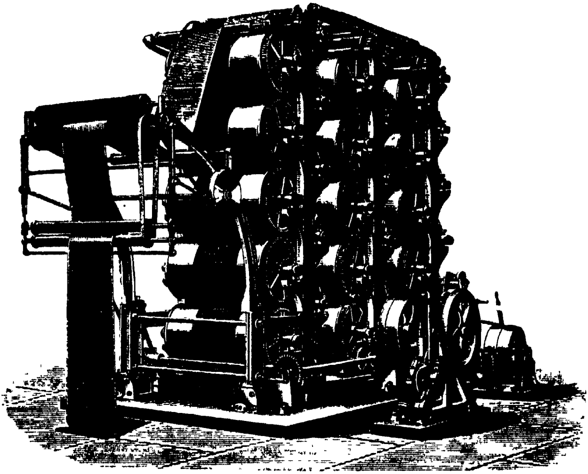

FIG. 8.—Roller Drying Machine.

CHAPTER III.

WATERPROOFING WITH ACETATE OF ALUMINA.

Preparation of Aluminium Acetate.—As an impregnating fluid acetate of alumina has great advantages. It is prepared by the waterproofer himself, and any one of the following methods of preparation may be employed: (1) Decomposing sulphate of alumina with acetic acid in the presence of chalk. (2) Decomposing sulphate of alumina with sugar of lead. (3) Decomposing sulphate of alumina with acetate of lime.

Alum can be used instead of sulphate of alumina, but the latter is generally preferred, not only because it is cheaper, but because it can be got on the market free from iron, or practically so. Freedom from iron is very important, especially if the fabrics have to be soaked in the waterproofing process. Method number 1 is worked as follows: Dissolve 30 lb. of sulphate of alumina in 8 gals. of cold water. Then add 36 lb. of 30 per cent acetic acid (sp. gr. 1·041). Then stir in, a little at a time, a paste consisting of 13 lb. of levigated chalk and 2 gals. of cold water.

The equation is: $Al_2(SO_4)_3 + 5H_2O + 3CaCO_3 + 4H_4C_2O_2$

$$= 3CaSO_4(H_2O)_2 + Al_2(HO)_2(C_2H_3O_2)_4 + 3CO_2.$$

The reaction, however, is not really so simple. No heat must on any account be used. On account of frothing due to the evolution of carbonic acid, the vessel must only be about two-thirds filled. It must be provided with stirring gear, not only to keep the chalk from sinking down but to get a uniform product. The chalk must be run in through a fine sieve (120 mesh) to keep back sand and dirt. When all the chalk is in, keep the stirrer going for five or six hours, and then allow the whole to stand. As decomposition is not quite complete even after twenty-four hours, the stirrer should be worked again for another six hours at the expiration of that time, and the whole then run off into a settling cask. After twenty-four hours in this, the solution of acetate of alumina can be drawn off from the precipitate of sulphate of lime. It is better, however, to effect the separation by centrifuging or by a filter press.

Filter Press.—A filter press consists of a series of filtering chambers, separated by solid partitions. They are included between two strong end pieces, one of which is fixed, the other movable. Filter cloths are put between the partitions, and must be large enough to prevent leakage at the edges. By means of levers, screws or hydraulic pressure, the whole contrivance is pressed into a single close mass, and we get a number of adjacent vacant spaces communicating with one another by openings, and into which the liquid to be filtered is pumped, or enters by its own weight. During this it is separated from solid matters, as it passes through the cloths, and runs off by special channels, while the solid matter remains in the filter press. According to whether the mass to be filtered enters in the middle or at the sides, and the space for the cakes is formed by the projecting edges of each pair of plates, whereby the cakes fall out freely when the filter press is opened, or the space for the cakes is formed by frames hung alternately with the filter plates, so that they can be lifted out with the cakes in them, filter presses are classified as *chamber presses* and *frame presses.*

Chamber presses have the advantage that they are of stronger build, and hence more durable. Two filter cloths are always in contact, so that they make a tight joint, and, as the opening in the centre of the chamber for the entrance of the stuff to be filtered is wide, there is no fear of the apparatus becoming choked. They have, however, the drawback that the filling of them with cloths takes a good deal of time; even if the cloths have been prepared by the best methods, the cakes have a hole in the middle instead of being entire.

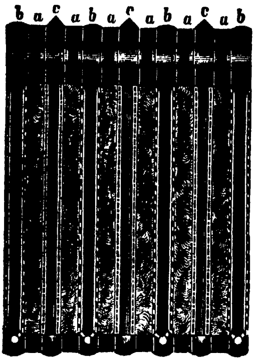

FIG. 9.—Plates of Three-Chamber Filter Press.

Frame presses have the advantage that they take less filter cloth, as each chamber is made tight by a single cloth. The cloths must not be stretched, and the cakes remain whole. Their disadvantage is that, on account of the smallness of the channels in their frames, they easily get choked, so that single chambers remain empty. After every operation the frames have to be carefully scraped and cleaned, that everything may be tight for the next time the press is used.

Three-Chamber Filter Press.—Besides the above systems, we have the three-chamber filter press, distinguished from the others by having no cloths, and containing instead layers of sand or charcoal. This press gives a specially clear filtrate. Fig. 9 shows the arrangement of the plates. Between every pair of frames, *a*, is a plate, *c*, while outside the frames the plates, *b*, are placed. The plates *b* and *c* serve to carry off the filtrate. The sand or charcoal is put into the frames, *a*, from above, and forms a solid cake from which the filtrate passes to the channels in *b* and *c*. When the frames, *a*, have thus been filled with filtering materials, the plates, *c*, are removed and replaced by the frames, *d* Fig. 10). The frames, *a*, and the plates, *b*, are not removed. As the filter cakes must be freed from the filtrate that clings to them, a rinsing arrangement must be attached to a filter press. For this purpose, two additional channels are provided in each filter plate—one to admit the rinsing water, the other for its escape. The first channel is connected with the filtering surface of every other plate only, whose draw-off cocks are shut, and admits water behind the cloths, and therefore behind the cakes. It goes through the first cloth and then through the cakes, then through the second cloth, and runs at the back of the latter away through the second channel, taking with it the liquid rinsed out of the cakes. The cakes are washed till free from acetate of alumina. All the wash water from the press which is not of lower gravity than 3° B. is used in waterproofing, and the weaker liquors are employed to dissolve the next lot of sulphate of alumina and to mix with the chalk instead of water. The cakes of gypsum left in the press have no value, and are thrown away.[1] The filter press is to be preferred to the hydro-extractor, as it gives a clearer filtrate and does not require such skilled and careful attention. A variation in the process described consists in stirring together 36 lb. of 30 per cent acetic acid, 13 lb. of levigated chalk, and 2 gals. of cold water, till the evolution of carbonic acid has nearly ceased. The mass is then left

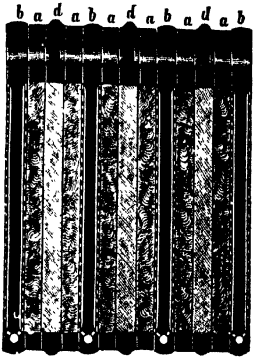

Fig. 10.—Frames and Plates of Three-Chamber Filter Press.

---

[1] They might be dried and used for paint purposes or as manures.

for a few hours, when a solution of 30 lb. of alumina sulphate in 8 gals. of water is poured in. After stirring till the fresh evolution of carbonic acid has ceased, proceed as before directed. It will be seen that this method of preparing acetate of alumina takes a long time, and is, on account of the use of acetic acid, rather expensive. The acetate of alumina obtained contains some undecomposed sulphate, but that is no bar to the use of the solution and does no harm. A considerable number of people consider that the best acetate of alumina for waterproofing is that prepared by the reaction between sulphate of alumina and acetate of lead. The proportions of the two to be taken are stated differently by the various authorities, as some take equal weights, some more acetate than sulphate, and some more sulphate than acetate. At all events cold solutions only must be used, and a mechanical stirrer is indispensable for proper work. Besides the mixing vessel with its stirrer, two smaller vessels are required, one for dissolving the lead salt and the other the sulphate of alumina. These vessels are placed above the mixing vessel, so that their contents can be run into it by taps. They are tilted so that the taps are at their lowest parts, and they can be completely emptied. The liquids are led into the mixing vessel by funnels closed by wire gauze for filtering purposes, and flowing together into the larger vessel. Water having been previously put therein, the stirrer is set in motion and the cocks are opened to let in the two solutions. When all is in, the stirrer is kept at work for about six hours. The liquid is run off into the settling cask and left for twenty-four hours to clear. The clear solution is then run off, and the precipitate is washed on filter cloths, or the whole is pumped directly into the filter press, which is afterwards rinsed out in cold water. Here, too, the liquors of not less than 3° B. are used in waterproofing and the weaker ones used for dissolving fresh lots of lead and alumina salt.

This process, too, is not very cheap, on account of the price of sugar of lead. The bye-product (sulphate of lead) certainly has some value, but only as a pigment, for which purpose it is very inferior in body to white lead. The conversion of sulphate of lead into white lead by boiling with carbonate of soda entails a good deal of labour and expense. As equally good acetate of alumina to that obtained as above can be got by cheaper methods, the foregoing processes should not be used except in case of necessity. When prepared by the second method, the acetate of alumina should contain an excess either of sugar of lead or of sulphate of alumina. This is of no consequence provided the waterproofing process includes a soaping, for in this case the excess is converted into insoluble soaps. If, however, the goods are not soaped, the solubility of the salt in excess detracts from the waterproofness. Fabrics containing an excess of sugar of lead acquire a blackish-grey appearance in air containing sulphuretted hydrogen, on account of the formation of sulphide of lead. Unquestionably the cheapest method of manufacturing acetate of alumina is to use sulphate of alumina and crude acetate of lime. The process is exactly like that from sugar of lead. The crude acetate of lime has a grey, sometimes nearly black colour, owing to the presence in it of tarry matters. The larger the proportion present of these the darker is the colour. Too tarry an acetate should not be used, as it gives a very dark solution of acetate of alumina which is not easily decolorized. The crude acetate of lime always contains carbonate of lime as well, and it is necessary to find out by trial how much of it is required to react with a given weight of sulphate of alumina. It is a good plan to keep solutions of both the ingredients in stock, ready for mixing in the proper proportions. The apparatus necessary is the same as when sugar of lead is used. The most usual proportions are 100 lb. of crude calcium acetate to

700 lb. sulphate of alumina, dissolved separately in water to a strength of 5° to 8° B. It is necessary to have plenty of room in the mixing vessel, to provide for the evolution of carbonic acid. When the evolution of gas has ceased, a sample of the mixed fluids should be taken, and part of it tested with chloride of barium, and part with sulphuric acid or with oxalate of ammonia. If the barium chloride gives a precipitate the sulphate of alumina is in excess, and if the other reagent gives a precipitate there is too much acetate of lime, so that after the test matters can be put right by adding more of whichever salt is deficient. This should be repeated till a precipitate is given in neither case. We then have an acetate of alumina which contains no more than traces of an excess of either ingredient. It is better to have an excess of sulphate of alumina than of acetate of lime. A small excess of the former does no harm, but an overplus of the latter is to be avoided. As in the other processes, the solution is run off and filtered through cloths or a filter press as already described. The cakes of sulphate of lime from the press can be used with lime and ashes for mending roads.[1] The acetate of alumina solution is generally used of a strength of from 3° to 5° B., but often from 6° to 8° B. It must be clear and give no colour with sulphuretted hydrogen. A white precipitate with that reagent shows the presence of zinc, a dark coloration the presence of lead or copper. If 5 cubic centimetres of the solution are mixed with 10 cubic centimetres of 90 per cent spirit, there must be no precipitate, but only an opalescence.

---

[1] [Such roads would be in a pitiable condition in wet weather. See note, p. 17 (REVISER).]

CHAPTER IV.

IMPREGNATION OF THE FABRIC.

Impregnation by Steeping.—The simplest, most primitive, and least to be recommended method of doing this is to steep the prepared fabric for twelve hours in the acetate of alumina solution. This method, if work is done on anything like a large scale, requires much space and labour and a large number of vessels, besides a large stock of acetate of alumina, as the pieces must be entirely immersed. As the pieces lie folded in the liquid, the outer parts of them absorb more than the inner, so that the impregnation is very far from being uniform. The consequence is that the fabric has to be treated with the acetate a second time. These difficulties can be avoided by using the sinker shown in Fig. 11. The fabric is there stretched on a frame provided with hooks. The frame consists of a vertical rod with a hook on it above and below. It carries a system of radial and concentric rods at each end. The lower system is fixed, but the upper can be raised or lowered at will. Both are liberally provided with hooks for stretching the fabric. The end of the piece is fixed in the middle, and the length is wound round and round the apparatus, so that the piece is hung up at full width. When the piece has been fixed the upper system of rods is raised so as to stretch it. The whole is then suspended by a chain in the impregnating liquor, which must be heated to 35° or 38° C. (95° to 100·4° F.). It is very difficult to heat a large volume of liquor uniformly. In this case it is impossible to use direct steam, for if the temperature rises above 38° C. (100·4° F.) the solution is precipitated in the form of a basic acetate of alumina and becomes useless. This precipitation takes place at once at the spot where the steam enters, and soon covers the perforated coil. Again, it is impossible to maintain a uniform temperature by stirring, as there is too large a bulk of fabric in the liquid. The lower part of the liquid is apt to become precipitated, as above stated, while the upper part remains unheated, and it is well to heat the aluminium acetate, even in the summer, while in winter it is a necessity. Many people try to avoid the difficulty by giving the fabrics twenty-four or even forty-eight hours in the solution, so as to give the heat every chance of becoming uniformly distributed. This, however, is not advisable, for some of the colour

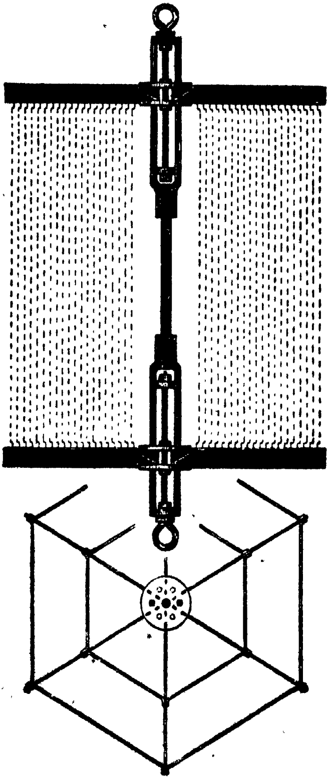

FIG. 11.—Sinker Apparatus for Stretching Fabrics during Impregnation.

left by the preliminary scouring (p. 5) then gets into the liquid and renders it unsuitable for further use. Whether this long sojourn in the acetate tenders the fibre or not is not yet certain. Experiments with a view to ascertain this are being carried on, but have not yet been concluded. The impregnation need not take longer than six hours, or eight at the outside, and when it is finished the liquid is run off by means of a cock placed at the lowest part of the vessel below the false bottom. It is then pumped into another impregnating vat for re-use. The fabric is left for a time on the false bottom to drain. During this time the pieces are turned over once, to prevent any part of them from being wetter than another. If the sinker has been used it is turned upside down after partial draining, and the framework is continually rotated. It is, however, in all cases better to effect the impregnation by mechanical contrivances. The jigger, the padding machine, and the roller printing machine all do excellent service in this way. Their use is the more to be recommended as they economize impregnating liquid. The pieces sewn together at the ends, are wound up either by hand or power upon a reel. It has proved advantageous to make these machines with semi-cylindrical bottoms and to allow the upper parts of the sides to separate far enough for the liquid driven out from the fabrics by the wringing to fall back into the box. The bottom of the box is fitted with a steam coil or better with a steam jacket for beating the liquid. A cock serves for emptying the box, which is made of deal or of iron, and lined with copper or indiarubber. At various depths within the box guiding rollers are placed, usually from two to five, in the liquid near the bottom, and the same number near the edge of the box and outside the liquid. There is also a pair of wringing rollers. The guiding rollers are of wood. The wringers are covered with indiarubber. The reels for the fabric are capable of having their rotation reversed, so that the cloth can be passed backwards and forwards through the impregnating liquid. A brake is used with the winding-off reel to give a certain amount of tension to the cloth. The arrangement of this jigger is shown in section in Fig. 12. A fabric runs full width under the guiding rollers in the liquid, then through the wringers, and then on to the receiving reel, and goes backwards and forwards till its whole length is properly impregnated.

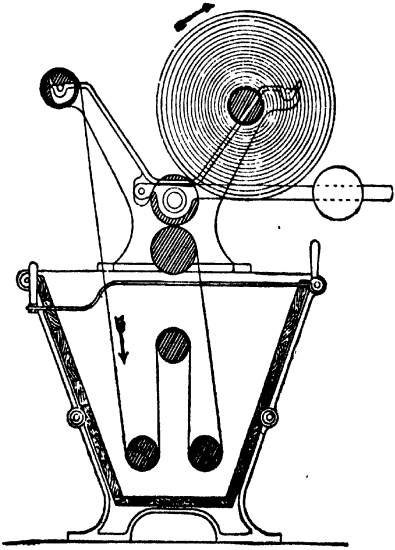

FIG. 12.—Jigger for Impregnating Fabrics with Waterproofing Fluid.

If we use a padding machine instead of the jigger, the stuff is wound off one roller, passes over guiding rods, and is spread out flat by a spreader. It then enters the trough containing the impregnating liquid. At the bottom of the trough are two or three wooden rollers and a copper steam coil. From the trough the fabric passes through a pair of indiarubber wringing rollers, and is then rolled up. As the entry and exit of the fabric are at the same side, the machine must be built extra high, so that it is possible to work the goods under it. The writer has seen in one factory a full-width washing machine used for impregnating, it being provided with reversing gear.

A somewhat different apparatus is that of Miller & Son (Fig. 13). This consists of a number of vats, C and D, containing the impregnating liquid, and ripped and perforated stretchers, K, from the inside of which the air can be exhausted, as well as of heated rolls, L, and one or more rollers, M, dipping into the trough, N. N is filled with hot substances soluble in water, through which the fabric travels.

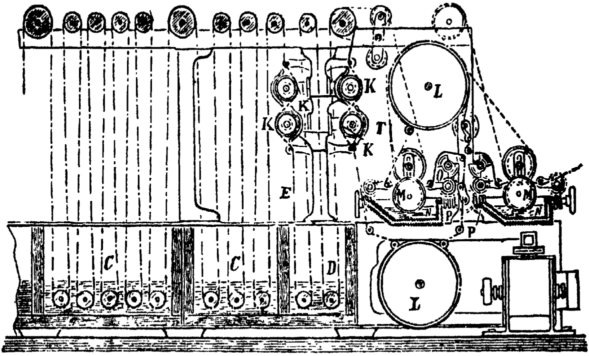

Fig. 13.—Machine for Impregnating Fabrics with Waterproofing Liquor (Miller & Son).

Whatever kind of apparatus is used, care must be taken to keep a proper quantity of impregnating liquid in the troughs, pouring more in as it is removed by the fabric; the specific gravity of the liquid in the troughs must be tested from time to time and reinforced if it has become too dilute. The fabric is passed backwards and forwards through the liquid for four to five hours, at the end of which time it will have become thoroughly soaked.

Vacuum Plant for Impregnating Fabrics with Waterproofing Liquors.—The most rational and rapid, and the cheapest, method of impregnating is by means of a vacuum. The necessary apparatus occupies very little room, requires little labour, and only small quantities of impregnating liquid, while the action is mechanical throughout. The apparatus is a cylinder made of iron or wood, and lined inside with thin sheet copper. The cover is removable, and with it a basket composed of thickly coppered iron rods, and having a smaller diameter than the cylinder itself, can be lifted in and out. The cylinder is vertical or horizontal according to the space available. The basket is divided into compartments by gratings or perforated plates, so that several lots of fabric can be impregnated at a time. The fabrics are wound up into loose rolls which are stood on end. The cylinder is provided with the necessary accessories for heating it, exhausting the air from it, etc., as well as cocks for admitting and removing liquid. The dimensions of the cylinder are so adjusted that very little liquid is needed to fill it. When the cage is filled with fabric and a vacuum has been made, the impregnating liquid is admitted into the cylinder. When it is full, as indicated by the gauge glasses provided, more is forced in by a pump, until there is a pressure of 2½ to 3 atmospheres inside the cylinder. This pressure is kept steady for from 30 to 45 minutes. The air and blow-off cocks are then opened, so as to drain off the liquid. This, after having been reinforced to the proper strength, is pumped back to the cylinder for a fresh operation. When the liquid has run out, the cover is removed and the basket is taken out. A fresh basket full of fabric has been got ready during the treatment of the first batch, so that it can be put at once into the cylinder, and the work can go on as nearly as possible without interruption. Mechanical arrangements, such as systems of levers, etc., are provided for this manipulation.

The process secures complete penetration of the fibre by the solution of acetate of alumina. The exhaustion of the air between the fibres and from the interior of the cells of the fabric gives the liquid free access to every part, so that every cell gets filled with it. This is, of course, also facilitated by the pressure put upon the liquid as above described.[1]

---

[1] [This latter vacuum process is identical with that used in the creosoting of sleepers (REVISER).]

CHAPTER V.

DRYING.

Drying Rooms.—After the fabric has been impregnated by one of the above methods, and has been drained of excess liquor as far as possible, it has to be dried. This process must be done at a high temperature, so as to ensure the formation of the insoluble basic acetate of alumina and to fix it in the fibre. During this reaction acetic acid is evolved and makes itself evident by its smell. The drying rooms are usually brick chambers, and must be roomy, so that the workpeople can move about in them freely in putting in and removing fabrics. They must also be provided with regulated inlets and outlets for hot, cold, and damp air. Every opening, including the doorways, must be closed by well-fitting doors, which should be bad conductors of heat. It is a good plan to have hollow iron doors filled with asbestos alum. The windows should have closely fitting iron shutters, by the closing of which any conflagration can be checked. The drying house should be divided into compartments separated by passages, and it is necessary to provide water and steam pipes inside, so that either water or steam is available in case of fire. The use of wood must be avoided wherever possible in the construction of the drying house, and what is used should be soaked in waterglass. Iron is to be preferred in building, and both the metal and the wood should be covered with several coats of good cement. The roof should be of concrete, sloping to each side from a ridge. The concrete should be covered externally with a smooth

INDEX.

A.

Absolutely waterproof fabrics, 37.
Acetate of alumina, 14 *et seq.*, 40, 41, 50.
— — iron, 54.
— — lead, 4.
Acetic acid, 15.
Adjective dyes, 55.
Alum, 4.
Aluminate potassium, 54.
Aluminium acetate, 14 *et seq.*, 22, 23, 50.
— hydroxide, 54.
— soaps, 40, 41, 54, 64.
— sulphate, 14 *et seq.*, 38.
Ammonia, removing vapour of, 52.
— soda, 5.
Ammonium cuprate, 4, 50-3.
Antimony soaps, 54.

B.

Beeswax, 38, 49.
Benzinger's collodion process, 66.
Bichromate, 64.
Bleaching, 56.
Boiler, 6.
Boiling (scouring) with soda lye, 5-8.
Breitenfeld's process, 52.
British waterproof patents, 77-128.
Brown fabrics, waterproofing, 54.
Brushing machines, 39.

C.

Calender steel, 39.
Calendering, 49.
Canal, D., 114.
Cartwright, G. A., 103.
Caseinate of lime, waterproofing with, 65.
Casteleyn, C., 123.
Cave, H. W., 117.
Cellulose, 50.
Ceresine, 4, 42, 45, 49.
Chazelles, M. J. R. T. R. de, 107.
Chevallot, E., 90.
Chisholm, W. O., 124.
Chromate of potash, 4.
Christie, E. J. C., 122.
Clark, H. A., 80.
Closmann, E. A., 112.
Cockhill, H. F., H. and E., 107.
Cohrs, H., 96.
Collodion, 66.
Coloured waterproof fabrics, 55, 56 *et seq.*
Company for manufacturing waterproof fabrics, 86.
Copper solutions, 50-3.
— sulphate, 4.
Coulter, W., 97.
Crabb, C. L., 110.
Cross, C. F., 94, 112.
Crushing the fibres, 39.
Currie, W., 80.
Cylinder (roll) drying machines, 11-13.

D.

De la Grange, E. S., 100.
— — Laye, E. D., 126.
Dickson, E. V., 81.
Dillberg, 113.
Dillies et Cie, 85.
Dittmar, H., 123.
Doerflinger, W. F., 125.
Doller, F., 93.

Doring's method, 74.
Douqué, A., 117.
Dreyfus, C., 93.
Drying machines, 8-13.
— — cylinder, 11-13.
— rooms, 28 *et seq.*
Dumas' waterproof method, 63.
Dutilleul, G., 103.
Dyeing, 55 *et seq.*
— apparatus, 56 *et seq.*

E.

Ebizuka, S., 113.
Edwards, E., 101.
Efrem, S., 105.
Eichengrün, A., 118, 119.
Electro Waterproofing and Dye Fixing Co., 97.
Erlwein, J., 100.

F.

Fastness to light testing, the, 57.
— perspiration, 57.
— wear, 57.
— washing, 57.
Felton, D., 78.
Felton's method, 53.
Filter press, 15.
— — chamber, 15.
— — frame, 15.
— — three chamber, 15.
Fink, M. W., 127.
Flöring, A., 109.
Fölsch, F., 120, 121.
Forster, T., 81.
Frame for hanging fabrics, 30-1.
Frankenburg, I., 85, 87, 89.
Frankenstein, P. and L., 85.
Freely, E. M., 90.

G.

Gademann, 84.
Galacher, S. F., 118.
Gafay, J. D. and B.D., 115.
Gaugl, M., 93.
Gelatin, waterproofing with, 60 *et seq.*
Genthe, 116.
Glafey, G., 83.
Golby, F. W., 121.
Gooch, R., 80.
Good, W. H., 98.
Goudie, J. N., 104.
Greening, F., 92, 100.
Grenet, P., 103.
Guide, C. de, 121.

H.

Haddan, H. J., 101, 103.
Hallet, B., 87.
Hanging fabrics in drying room, 30 *et seq.*
— tarpaulins, 73.
Hardinn, N., 84.
Hardmann, R. B., 94.
Hart, A. M., 114.
Hasenbring, C., 122.
Hatmaker, J. R., 106.
Hanbold arrangement for cylinders, 12.
Haug, J. J., 89.
Healey, A. E., 79, 95.
Hebblewaite, J., 86.
Heitz & Co., 127.
Hendricks, V., 96.
Henley, W. T., 83.
Hepburn, G. G., 99.
Hiller, O. B. E., 86.
Himes' process, 52-3.
Hoffman, C., 89.
Holfert, J., 95.
Holt, E., 86.
Honzeau & Maison's process, 75.
Houghton, H., 79.
Hull, J., 106.
Hutchinson, T. J., 94.
Hydro extractor, 73.

I.

Illingworth, T., 80.
Impregnating machinery, 21-7.
Impregnation of fabric, 21-7.
— duration of, 22-3.
Indiarubber, solution of, 38.
— vulcanised discovery of, 76.
Iron soap, waterproof with, 54.
— sulphate, 4.

J.

Jaeger, P., 108.
Japan wax, 38.
Jigger, dyeing in the, 56.
— impregnating in the, 23.
Johnson, D., 80.
— J. Y., 111.
Johnston, G. G., 126, 127.

K.

Kaufmann, 108.
Keir, 7.
Kershaw, H. E., 109.
Kipling, W. C., 97.
Klugmann, J., 110.
Knorzer, C., 113.
Knowles, J., 79.
Kochmann, C., 108.
Kraemer, G., 112.
Kronstein, 100.

L.

Lake, H. H., 104.
— W. E., 125.
Landry, A., 81.
Lapisse, E., 121.
Lawrence & Co., 98.
Lead acetate, 18.
— soaps, 54.
— sulphate, 18.
Leduc, Hertz & Co., 127.
Le Bossays, F., 120.
Leishman, T. L., 111, 128.
Lender, R., 128.
Lilienfeld, L., 125.
Lister, S. C., 86.
Luft, A., 105.

M.

McRain, G., 125.
Macintosh & Co., 97.
— H., 113.
Mackintoshes, 77.
McKerrow, C. A., 173.
McLennan, A., 116.
Mandleberg, G., 89, 91.
Marga, U. A., 108.
Marks, H. C. R., 121.
Maurel, J. P. L., 109.
Maxwell, W. G., 122.
Mayhew, H., 114.
Menzies, J., 105.
Metallic soaps, waterproofing with, 54.
Miller's machine, 25.
Mills, C. K., 114.
Mitchell, T., 123.
Möller, T., 114.
Mordants, 55.
Mossner, J., 93.
Muratori, C., 78, 81.
— and Landry's method, 62.
Muzmann and Krakowitzer's method, 63.

N.

Neville, J., 79.
Newman, G. F., 98, 102.
Northrop, J., 80.

O.

Oesterheld, A., 101, 102.
Oesterreich, J., 96.
Olivet, W., 92.
Olivier, M. G., 98.
Olsen, M., 104.
Orlay, C., 90.
Ozokerit, 42.

P.

Padding machine, dyeing with, 56.
— — impregnating in, 24.
Paraffin wax, 4.
— — waterproofing with, 41-9.
Parnell, A. H., 128.
Patents, British waterproof, 77-128.
Pearson, H. P., and Pearson's Patents, Ltd., 115.
Peck, C. A., 116.
Plonnis, R., 113.
Port, G. M., 101.
Punshon, R., 90.
Pyroxylin, 66.

Q.

Querin, E. N., 124.

R.

Reid, W. F., 107-8.
Reixach, J., 86.

Rendle, C. P., 118.
Rinsing filter cakes of alumina, 17.
Robinson, J., 93.
Ronchetti, R. F., 115.
Rothenbücher, M., 104.
Rous, H., 95.
Rowley, T., 81.

S.

Sage, A. A., 110.
Salamonson, A. C., 81.
Sandron, A., 88.
Sandtner's method, 64.
Schlomann, H. W., 99.
Schoowalter, H., 109.
Schulke's method, 64.
Scouring, 5.
Shepherd, J. A., 109.
Sinker for impregnating fabrics, 22.
Slade, W. H., 88.
Soap, 4.
— recipe, 38.
Soaping the goods, 37.
Soc. Anonyme des Celluloses Planchon, 124.
Soda ash, 5.
Spence, J. B., 82.
Spreading machines, 69.
Stanley, J. H., 110.
Steel calenders, 40.
Staples, E. C., 99.
Stephens, E., 97.
Stove in the drying house, 33.
Sulphate of lead, 18.

T.

Tannate of gelatine, 51.
Tannin, 55.
— waterproofing with, 60.
Tar-boiling, 67.
Tar oils, 74.
Tarpaulin, manufacture of, 67.
Tarring fabrics, 67.
Taylor, J., 98.
Testing waterproofing, 40-1, 57, 72.
Tin soaps, waterproofing with, 54.
Turner, E. M., 95.

U.

United States Waterproofing Fibre Co., 90.

V.

Van Gestel, J. T., 99.
Verdier, R., 96.

W.

Walker, J., 82.
Warner, C. B., 91.
Washing machine, 8.
Waterproof patents, British, 77-128.
Waterproofing dyed goods, 57.
— with aluminium acetate, 14.
— — ammonium cuprate, 50 *et seq.*
— — caseinate of lime, 65.
— — gelatine, 60-2.
— — tannin, 60-2.
Watzlawik, F., 100.
Weber, C. O., 98, 104.
Weir, J., 94.
West, G. N., 95.
Weygang, C., 84.
Wharton, F. M., 103.
Wicks, R. P., 85.
Wiley, T. F., 87, 89, 107.
Williams, J., 95, 99, 104.
Wilson, G. F., 91.

Z.

Zinc soaps, waterproofing with, 54.
— sulphate, 4.

ABERDEEN : THE UNIVERSITY PRESS